A31s

AK132s

ACCESSION NR: AT4031764 S/0000/63/000/000/0074/0099

AUTHOR: Kuznetsov, O.P.

TITLE: Relay devices and finite automata

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 74-99

TOPIC TAGS: control system, automatic control, feedback, relay, automaton, finite automaton, black box problem

ABSTRACT: The article deals with several fundamental results achieved in the theory of automata and their interpretation in terms of relay devices. In the first section of the paper, the author has analyzed different models of finite automata, the concept of the event and the formulation of the problem of synthesis. It is shown that the evolution of the theory of such automata began with the investigation of abstract nerve nets (W. McCulloch, W. Pitts. A logical calculus of ideas immanent in nervous activity. "Bull. Math. Biophys.", v. 4. S. 1943, p. 115-123; S. Kleene. Representation of events in nerve nets and infinite automata. Automata Studies Princeton, 1956). The concept of the "finite automaton" (a term introduced for the first time by S. Kleene) is examined.

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The Moore model (Moore sequential machine) is discussed and described (E. Moore. Gedanken-experiments on sequential machines. Automata Studies. Princeton, 1953) and the Mealy model is defined (G. Mealy. A method for synthesizing sequential circuits. "Bell System Tech. J," v. 34, no. 5, p. 1045-1079). The work of Yu. T. Mendeleyev on events representable in finite automata is placed in proper perspective in terms of the general discussion of the problem (Yu. T. Mendeleyev. O klasse soby*tiy, dopuskayushchikh predstavleniye v konechnom avtomate. Sb. "Avtomaty*", dobavleniye 2, 1956). The application of the flow table, introduced by D. Huffman (D. Huffman. Synthesis of sequential switching circuits. J. Franklin Institute, v. 257, no. 3, p. 161-190; no. 4. p. 275-303, 1954), to the investigation of sequential relay devices is discussed and the use of such tables is described. Various definitions of an "event" are given. These definitions are taken, for the most part, from the writings of Kleene and Mendeleyev. In this connection, the importance of the concept of "regularity" (in terms of a regular event) is shown to be determined by the following two theorems: 1) For every regular event there exists a finite automaton to represent it; 2) Every event representable in some finite automaton is regular. Both theorems are proven and discussed. Further theorems (again taken primarily from the work of S. Kleene referenced above) are analyzed in terms of the algorithmization of abstract automata synthesis according to a given finite system of regular events; for example: For every definite event there

exists a nerve net without loops: and, for every given nerve net without loops and every given internal neuron of this net, excitation of this neuron is equivalent to the advent of some definite event. The work, in this area, of V. M. Glushkov (V.M. Glushkov. Ob odnom algoritme sinteza abstraktny*kh avtomatov. Ukr. matem. zhurnal, no. 2, 1960) is considered, along with an analysis of the technical applications of the theory of abstract nerve nets to the theory of logical circuits. Logical and delay elements are considered, and it is shown that the physical realization of logical nets is found in devices with pulse condition, in which the transmission of information is possible in one direction only. The author notes that, after the problem of representability had been solved in principle (by S. Kleene), two fundamental problems of automata synthesis have emerged: the search for various languages in which to write the events and the construction of automata to perform assigned operating conditions with a minimal number of states. An analysis is given of certain of the results achieved in this area by Yu. T. Mendeleyev, N. Ye. Kobrinskiy and B. A. Trakhten. brot (N. Ye. Kobrinskiy, B. A. Trakhtenbrot. O postroyenii obshchey teorii logicheskikh setey. Sb. "Logicheskiye issledovaniya", 1959), A. Church in a number of articles, E. Berkley (E. Berkley. The algebra of states and events. "Amer. Math, Monthly", v. 78, no. 4, 1954) and others. The author's view of this problem area may, perhaps, be summarized as follows: In the synthesis of single-cycle devices, for the inscription of the operating conditions a standard language is employed - a Boolean function, assigned in the form of a formula or a table. The problem of synthesis thus is

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reduced to one of minimization. For automata, synthesis becomes more complex. While for single cycle devices it is always possible to assign a finite list of input symbols and corresponding outputs, the list of possible symbol sequences (that is, an event) may be infinite, and its structural or design assignment resolves itself to the problem of devising (constructing) a language in which infinite lists are given by finite formulae. The second source of complexity is seen by the author in the fact that not all events are susceptible of representation in an automaton - whence the second requirement of the language: in it it must be possible to distinguish representable events from those which cannot be represented. In the language of regular events, this problem is solved in a simple fashion: non-representable events are not described in it; that is, the very fact that a formula exists which corresponds to a certain event is evidence of the representability of that event. However, the author notes, this is not always the case. For example, in a language in which it is possible to describe all events (such a language will contain recursive definitions) the problem of recognizing the representability of events cannot be solved algorithmically. With respect to the advantages of the languages proposed by the various authors and considered in this article by way of review, that is, the possibilities of a simple transition from a verbal formulation of the conditions of operation to an economical base formula, it is, in the author's view, senseless to search for a universally simple language, since problems will always be found which can be more simply described by

another language. The selection of one language over another will in all likelihood be determined not by individual and separate problems, but by the possibility and ease with which a large number of different working conditions can be classified by the terms of the particular language. The second part of the article deals with the analysis and minimization of finite automata. The so-called "black box" problem is considered, with the author presenting the results, employed, as he claims, without strict proof, by Huffman, in the formulation of G. Mealy. The author concludes that, according to the theory of finite automata, a relay contact system is a particular form of finite automaton. The circuitry of the automaton is derived by assigning to each state a binary number representing an ordered set of intermediate element states. Since this attribution is arbitrary (with the limitation that one number cannot be ascribed in two states), corresponding to an automaton, given by a flow table, will be an infinite number of devices, different in structure but equivalent in action. The particular attribution depends on our requirements of the structure of the device: do we wish completely to eliminate race conditions, obtain a maximally simple logic part of the device, achieve protection against a given number of faults on the part of the elements of the device, etc. It is, however, preferable to minimize the number of states before the attribution. In this case, all methods of finite automata minimization are applicable to relay-contact devices. On the other hand, the methods of synthesis existing in the theory of automata cannot be unconditionally applied to such devices, since these methods effectively synthesize not the abstract finite

automaton,that is, the flow matrix (or table), but a particular instance of the finite automaton - the logical net; that is, a synchronous automaton. Asynchronous automata, however, (particularly, relay-contact devices) differ from the synchronous in a number of properties, connected with the fact that asynchronous automata operate not in pulse, but in potential mode. In sum, the fundamental problems of the first step in the synthesis of relay-action devices (ending with the coding of the states) may, in the opinion of the author, be formulated as follows: 1) The search for effective logico-mathematical languages which will make it possible to write the operating conditions in terms of input and output sequences and to obtain, from this method of writing, tables which will define the automaton; that is, a state table (flow table) and output table. 2) The minimization of the flow table of the automaton, for which not all input sequences are permissible. 3) Optimal state coding by binary numbers in order to reduce the number of logical elements of the automaton (in the case of a relay-contact system - the minimization of the contact part), and to secure the construction of reliable structures and the elimination of race conditions. Orig. art. has: 11 tables, 11 formulas and 12 figures.

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Card 7/7

ACCESSION NR: AT4031765 S/0000/63/000/000/0100/0109

AUTHOR: Kuznetsov, O. P.

TITLE: One class of regular events

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 100-109

TOPIC TAGS: control system, automatic control, relay, regular event, nerve net, finite automaton

ABSTRACT: The concept of the regular event was introduced by S. Kleene (Representation of events in nerve nets and finite automata. Princeton, 1956), who demonstrated that the class of regular events coincides with the class of events which may be represented in a finite automaton. This result was later refined (V. M. Glushkov. Ob odnom algoritme sinteza abstraktny*kh avtomatov. Ukr. matem. zhurnal, no. 2, 1960) and it was shown that for any system of regular events, containing N letters of the input alphabet, an automaton can be constructed to represent this system, with a number of states $\leq 2^N + 1$. While it

can easily be demonstrated that the number of states can be reduced by a factor of four, its exact value is as yet unclear. Noting the interest in determining the subclasses of regular events with a simpler estimation of the number of states of the corresponding automatic devices, the author has given such an estimate in the present article for a class of definite (in the sense of Kleene; see reference above) occurrences; that is, occurrences of the type <J> A, where J is a union of all the letters of the alphabet, and A is a formula which contains no iterations. The approach to the problem rests on the assumption that the automaton is represented by a transition diagram (flow table), that is, by an oriented graph, the apices of which correspond to the states, and the ribs — to the transitions from one state to the other. Corresponding to each such graph the author postulates a matrix C of unions and a matrix C* of paths (O. P. Kuznetsov. Releyny*ye ustroystva i konechny*ye avtomaty* (this collection)). Element C_{ij} of matrix C is the union of the weights of all the ribs leading from state s_i to state s_j; element c_{ij} * is the union of all the paths leading from s_j to s_i. It is evident that $c_{ij} \subseteq c_{ij}^{*}$. In the matrix of the automaton for any i, j, and k we have $c_{ij} \not\subset c_{ik}$. This ratio expresses the condition of unambiguity of the transitions in the automaton. The following theorem is advanced in the article: Let there be given a system of n occurrences

$$\langle I \rangle A_1, \ldots, \langle I \rangle A_n, \quad (5)$$

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where $A_1, \ldots, A_n$ are formulas containing no iterations; $\langle I \rangle$ is a set of all the words in the input alphabet. Then the minimum number of states of an automaton representing system (5) by outputs 1. . . ., φ_n, respectively, will not exceed N + 1, where N is the total number of letters in the divergent form of the formula

$$A_1 \vee \ldots \vee A_n. \tag{6}$$

The idea of the algorithm for constructing this automaton is contained in the following evident lemma: Let there be given an event A and an automaton, in which there is separated an initial state s_0 and a subset of states F, such that: 1) for any state s of the automaton every word $P_A \in A$ shifts the device from state s to $s_F \in F$; 2) every word which shifts the device from s_0 to s_F can be represented in the form $P_1 P_A$, where $P_1 \in \langle I \rangle$, $P_A \in A$. Then the given automaton represents the occurrence $\langle I \rangle$ A by a set of states F. The steps involved in this algorithm are discussed in the article, another lemma is proposed and examples are given in the concluding section. Orig. art. has: 2 figures, 5 tables and 16 formulas.

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A315

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AUTHOR: Tomfel'd, Yu. L.

TITLE: Method for ordering the states of intermediate elements in the synthesis of multicycle relay devices

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 110-127

TOPIC TAGS: control system, automatic control,race condition, feedback, relay, multicycle relay, intermediate element, element ordering

ABSTRACT: In this long article a method is discussed for ordering the states of the intermediate elements of a relay device, which provides the possibility of achieving a relay device without inadmissible race conditions on the part of the secondary elements. Relay devices are first considered, for the synthesis of which operating conditions are assigned in the form of the flow table, minimalized in terms of the number of lines as proposed by Huffman (D. Huffman. Synthesis of sequential switching circuits. "J. Franklin Inst.", v. 257. N. 3, 4, 1954). Synthesis problems are analyzed on the basis of this table and a very important and most frequently encountered particular problem of assigned relay device working conditions is considered; namely, the absence of cyclically or periodically interchangeable output states with constant input state. In the further exposition of this

problem the flow table is considered as the assignment of the secondary states and transitions between them, it being necessary to specify the secondary states during the synthesis process, with the possibility of introducing permissible changes into the prescribed conditions. The discussion follows in general terms the exposition of Huffman in the work mentioned above, particularly with respect to the author's explanation of k-sets and race conditions and their application to relay devices operating under "real" conditions. Permissible k-set operations during relay synthesis are analyzed (the author frequently introduces his own terminology and thus refers to Huffman's k-sets as "δ-subgraphs." The terms "δ-matrices," "δ-sets," "σ-graphs," derived from flow diagram analysis, are also introduced and explained). Various methods, as proposed by different authors, for arranging the states by lines are discussed. These methods, the author claims, are based on experience and intuition, or else make use of a redundant typical arrangement, constructed for those cases in which the transitions (flows) are present between all pairs of lines of the flow table and which does not yield critical race conditions for the intermediate elements. In the ordering of the states a unit n-dimensional cube (hypercube) is used (see Fig. 1a in the Enclosure). A binary n-place number is assigned to each apex of the cube. Each rib connects two adjacent numbers, differing only in one place. If the number of variables n is small (to 5 or 6), the hypercube may be conveniently represented in the form

of a graph (Fig. 1b). What is taken is the result of the imposition, one on the other, of the σ-graphs of all the columns of the flow table and the fusion of the apices, relating to the single lines, and the ribs, imposed one on the other. This result is called a state diagram or state graph. If the state graph is superimposed on the hypercube (introducing, if need be, new apices into the state graph and new lines into the flow table), then the binary numbers at the apices of the hypercube will characterize the states of the intermediate elements. By virtue of the nature of the hypercube, all transitions between the states of the relay device will be accompanied by a change in the state of only one intermediate element and, consequently, no element race conditions will be present. A new intermediate state may be introduced into the state graph. However, transition substitution in it is impossible without first checking the special conditions connected with the δ-subgraph isolation requirement. This fact limits the possibilities of this method of ordering secondary states — all the more since the originally assigned, untransformed δ-subgraphs are star-shaped in form with a steady state in the center and with a rib number equal to the number of unstable states. When imposed, they result in a graph with a large number of transitions between apices, which makes it difficult to align the graph with the hypercube. The method proposed in this article for ordering the states of two-position secondary relay elements, while it does not yield impermissible race conditions, does permit the acquisition

of permissible race conditions, if this should be required in order to increase operational speed or for the minimization of the circuits acting on the intermediate and final (performing) elements. Like the others, this method is based on the use of a hypercube; however, rather than combining the state diagram with the hypercube, there is a sequential "stretching" onto it of δ-subgraphs belonging to one σ-graph. In the transition from one σ-graph to the other, a new hypercube is taken and there is transferred to it the information with respect to the disposition of the apices of the σ-graphs, for which the state ordering operations have been carried out. Preserved on the former hypercube is the information as to how the apices of the corresponding σ-graph were arranged and what transitions exist between them. This permits the subsequent determination of the functions and, consequently, the structure of the circuits affecting the intermediate and acting elements. On the new hypercube the δ-subgraphs of the new σ-graph are sequentially ordered. The ordering of the δ-subgraph begins with locating the steady state or, if it does not coincide with the apex of the hypercube when the preceding σ-graphs have been "stretched," the place for it. The place for the steady state is selected so as to be adjacent to any of the apices, present on the hypercube, of the δ-subgraph being worked, and an arrow is used to indicate the direction of the flow along the rib of the cube from this apex to the apex selected

for the steady state. Then the transitions from the states not connected with the steady state to the steady state are established. Meanwhile, transition variants may be found by using both the apices relating to the given δ-subgraph as well as the free apices. In order to establish the flow (transition) from one apex of the processed δ-subgraph to another, as an intermediate apex there may be employed the intermediate apex given in one of the flow variants of an already worked δ-subgraph of the given σ-graph (if there are more than one of these variants). At this point also the disrupted δ-subgraph is restored, but no longer with the corresponding flow variant. After the flows between the apices, present on the hypercube, of the processed δ-subgraph have been determined, the sites for its apices which have not yet been arranged on the cube are found. These sites are selected either where intermediate states have been introduced or in the unoccupied apices of the cube located adjacent to the ordered apices of the δ-subgraph. Flow substitution and the introduction of new states, in this process, take place automatically and only as needed. At first, for the purpose of operation, a unit n-dimensional cube is taken of such order $n = n_{min}$ that $2^n \geqslant N$, where N is the number of lines of the base minimalized flow table.

If, later on, during the process of the work, it should be found to be impossible to order the necessary δ-subgraph apices or to establish the required flows, then the hypercube is expanded by adding one dimension; that is, there is a transition from an n-dimensional

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to an (n + 1)-dimensional cube. This method is developed and illustrated on the basis of practical examples in the article. Orig. art. has: 8 figures and 14 tables.

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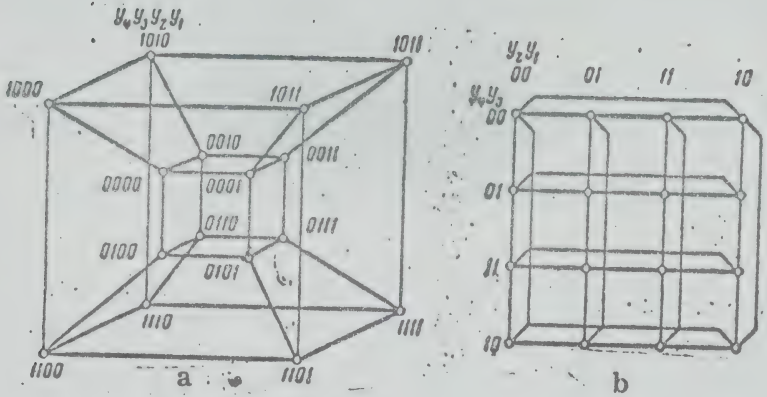

Fig. 1. Unit four-dimensional cube (a), and unit four-dimensional cube in the form of a graph (b).

A31S

ACCESSION NR: AT4031767 S/0000/63/000/000/0128/0144

AUTHOR: Parkhomenko, P.P.; Tomfel'd, Yu. L.

TITLE: Minimization of the number of essential connections between the lines of a flow table

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 128-144

TOPIC TAGS: control system, automation, automatic control, feedback, flow table, relay, relay structure

ABSTRACT: The authors have arbitrarily broken down the process of relay device structural synthesis into the following five stages: (1) The verbal description of the problem; that is, the verbal exposition of the relations between the assigned sequences of input influences and the required sequences of output influences corresponding to them, as well as instructions regarding additional requirements and constraints. (2) The representation of the verbal assignment of the future relay device in formal language, suitable for the further processing of the problem. (3) Feasibility check of the assigned operating conditions,

determination of the necessary number of secondary (intermediate) elements, and the ordering of their state combinations so as to exclude impermissible race conditions. (4) The construction of a truth table (table of states, table of a single-cycle equivalent of a multi-cycle (i.e., "sequential") system), with consideration of the secondary elements. (5) The construction of a structure to satisfy the derived truth table and the additional requirements and constraints. It is noted that, as a rule, and in a certain sense optimal solution must be achieved in the second, third and fifth synthesis stages, with the criteria of optimality, in the simplest case, being minimum sequence length, minimum state number and minimum element number. The present article deals with problems relating, primarily, to the third stage in the synthesis of relay device structure. The synthesis problem using flow tables is considered on the basis of the following example: a relay device is to be constructed which will provide a means whereby any of three water-pipe filters will be switched over for washing in the same order (sequence) in which they become clogged. The filters are to be switched for this washing operation one at a time. State and flow tables, corresponding to this problem, are calculated and analyzed. General rules for joining the lines of the tables are derived and applied. The compression operation is discussed in terms of the selection of the possible variants of line union. It is demonstrated that the problem of

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minimizing the number of lines of a flow table reduces itself in this case to a reordering of the lines and columns of the compression matrix in such a manner as to obtain from the given matrix a minimal quantity of diagonal blocks, having no empty non-diagonal cells. The authors described how this operation is accomplished in actual practice, and then turn their attention to the problem of the determination of the necessary number of secondary elements and the arrangement of the combinations of their states; that is, the matching of these combinations to the numbers of the states of the secondary elements of the device (the line numbers of the compressed flow table). The method described is essentially that proposed by S. Caldwell (S. Caldwell, Logicheskiy sintez releyny*kh ustroystv. M., 1962). A method is explained for minimizing the number of ribs of a flow graph, based on the possibility (described in the article) of redistributing the connections (relations) between the lines of the flow table. The possibility of such minimization in general is shown to flow from the ambiguity of the solution of the problem. In the given case, the ambiguity is present when there are three or more single sate numbers (one of which is normally steady) in at least one column of the flow table. Extensive flow variation tables are given in the article and their use is explained in detail. It is pointed out that when compiling such a table, the different constraints imposed on the flows (transitions) can be taken into account. For example, transitions of more than two cycles

to steady states can be forbidden for part or for all of the lines. The table of variants should not include those flow variants which do not satisfy the limitations adopted. Consequently, the minimization of the number of ribs of a flow graph is reduced to a rational selection of l lines (one line from each group corresponding to one steady state) of the table of variants. The point is further made that all possible solutions of the minimization probably can be achieved by representing the table of variations in the form of a certain algebraic formula (similar to the McClusky formula representing a Quine table in the minimization of Boolean functions) and subsequent transformation of this formula to the form of the sums of the products of the logical variables, which in the case considered in the article are the flows (transitions) between the lines of the compressed flow table. The limitations and peculiarities of this method are noted and analyzed. Orig. art. has: 5 figures and 11 tables.

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ACCESSION NR: AT4031768 S/0000/63/000/000/0148/0162

AUTHOR: Didenko, V.P.

TITLE: Several methods for the minimization of Boolean functions

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 148-162

TOPIC TAGS: control system, automatic control, relay, Boolean function, minimization, Boolean function minimization

ABSTRACT: The article begins with a review of the known methods for the minimization of Boolean functions. It is pointed out that the majority of these methods use, in the first stage, the following operations:

$$
\begin{aligned}
&1)\ Ax + Ax = A;\\
&2)\ A + A = A;\\
&3)\ A + \bar{A}B = A + B;\\
&4)\ A + AB = A;\\
&5)\ Ax + Bx = Ax + Bx + AB.
\end{aligned}
\qquad (1)
$$

In the second stage they employ either the absorption operation or the Quine-McCluskey table. Methods which make use of the absorption operation are dismissed as inapplicable to the construction of minimal expressions of incomplete truth functions. The author sees the general deficiency of those methods which use the Quine-McCluskey table in the fact that the table of coverings, employed in the second stage, serves as an intermediate link for the transition to the algebraic writing of the general minimal form, which, in the event of programming on universal computers, requires an additional expenditure of a considerable part of the operational memory of the machine, as well as a large number of intermediate operations. This assertion is analyzed in some detail. Attention is also called to the fact that, in the second stage of minimization, the kernel of the minimal expression of the Boolean function is normally separated either during the computation process or during the final stage, which also entails the expenditure of superfluous operations. This leads the author to pose the following three problems: 1) The preliminary separation of the kernel of the minimal expressions of Boolean functions for given F_1 and F_0 without the separation of unessential minimal terms; 2) Elimination of the intermediate operation

$$F_1 \left(\bigvee_{i=1}^{k} U_i \right) = 0;$$

3) The construction of minimal or near-minimal expressions without the determination of the general minimal form. In the present article, two methods are proposed: the method of incompletely-specified minimal terms, and the method of obligatory components. The first method for the separation of essential minimal terms (a minimal term is called essential in the event, and only in the event, that its removal from the general minimal form leads to

$$\bigvee_{\substack{i=1 \\ i \neq i}}^{p} U_i F_1 \neq F_1. \qquad (2)$$

rests on the following theorem: If the elementary conjunction U_k, composed of the obligatory letters of set $\tilde{\alpha}$, for which $f(\tilde{\alpha}) = 1$, satisfies the ratio

$$U_k F_0 = 0,$$

then it is an essential minimal term. The proven theorem makes it possible to separate all essential minimal terms of the complete normal form, given on sets M_{F_1} and M_{F_0}, of a Boolean function and, thus, to separate its kernel without determining the general minimal form. Fundamental to the second method is the

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theorem: Every conjunction (disjunction), composed of letters which correspond to the obligatory numbers of the sets, is a minimal term. This theorem is the foundation for the algorithm for constructing minimal terms and, consequently, for the general minimal form. Both methods are considered in detail and specific cases of their application are analyzed. Orig. art. has: 2 tables and 10 formulas.

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A315

ACCESSION NR: AT4031769 S/0000/63/000/000/0163/0169

AUTHOR: Kazakov, V. D.

TITLE: Minimization of Boolean functions with consideration of the operation of removal from parentheses

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 163-169

TOPIC TAGS: control system, automatic control, relay, Boolean function, minimization, Boolean function minimization

ABSTRACT: The author notes, by way of introduction, that the classically derived minimal expressions of Boolean functions of the type sp or ps are not, in the majority of cases, genuinely minimal, since the application to such expressions of the laws Ax + Bx = (A + B)x and (A + x) (B + x) = AB + x makes it possible to shorten them. As a result, expressions of a more complex form are obtained: sps... and psp. Since their writing includes parentheses, such expressions have become known as parenthetical expressions. Referring to the work of Abhankar (Minimal 'Sum of products of Sums"expressions of Boolean functions. IRE Trans., v. EC - 7, no. 4, p. 268-276, 1958), the author calls attention to the problem of finding new regular methods of minimization, which will make it possible to find absolutely minimal

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expressions of arbitrary Boolean functions. In the present paper, a short description is given of possible algorithms for finding absolutely minimal expressions of given Boolean functions along with an approximate estimation of the number of elementary operations necessary to achieve absolutely minimal expressions of functions at a given number of variable n. The result obtained permits the assertion that it is practically impossible to find absolutely minimal expressions when $n \geqslant 4$ and, thus, directs attention to another problem — that of the parenthesis treatment of minimal sp- and ps-expressions. In the first part of the article, basic definitions are introduced and the statement of the problem is formulated. The problem is stated by the author in the following terms: find an algorithm which will make it possible to discover Z(f) of a given function f. In this connection, it is pointed out that the widely-used designation of this problem — finding minimal parenthetical expressions of a given Boolean function — is inexact, since there may be z(f), the writing of which does not involve parentheses (for example, $x_1 + x_2$ or $x_1 + x_2x_3$, etc.) and, conversely, the presence of parentheses even in a minimal ps-expression by no means guarantees that there will not be found a z(f) among expressions of a more complex form. In the author's treatment of the problem, the finding of Z(f), Zsp(f) and Zps(f) requires the use of two fundamental operations: (a) finding the items of the given function; that is, such g_i that

$\sum g_i \sim f$, where f is a given function; (b) finding the cofactors of the given functions; that is, such as h_i that $\prod h_i \sim f$, where f is a given function. The author then proceeds to find the minimal expressions, the form of which is written by means of a finite number of symbols ε and p. After this, Z(f) is derived. The article concludes with an estimate of the number of elementary operations required to discover Z(f) for an arbitrary Boolean function and variables. By "elementary" the author understands here a comparison for "equivalence" and Boolean addition. It is noted that the analysis, necessary in order to derive the Z(f) of Boolean functions of more than three variables, is practically impossible, even with the help of computers. Orig. art. has: numerous formulas.

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ACCESSION NR: AT4031770 S/0000/63/000/000/0170/0179

AUTHOR: Vorzheva, V.V.

TITLE: Investigation of the structures of relay devices from the point of view of their operation on real contacts

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 170-179

TOPIC TAGS: control system, automatic control, feedback, relay, relay structure, relay operation, electromagnetic relay

ABSTRACT: For convenience's sake, only electromagnetic relays are considered in this article. The coils of these relays are designated, in the nomenclature adopted by the author, by capital letters, while their contacts are designated by small letters. The results obtained in the study are applicable to relay devices using elements of various types. The conductivity of an individual circuit or of the entire system is, the author claims, a function of the system structure and of the variation of the input values of the system. Circuit conductivity is designated by the letter F: when the circuit or system conducts, F = 1; when it does not, F = 0. The output operating conditions of

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a relay device are described by a Boolean function, represented in the conjunctive or disjunctive normal form. The author notes that in relay device analysis and synthesis normally no consideration is given to the possible changes in the sequence of interaction of the different contacts of one and the same relay (normally open and normally closed); that is, such studies are based on the concept of ideal contacts and on the assumption that, when the relay is tripped, the normally closed contact is broken simultaneously with the making of the normally open contact. Under such assumptions, systems which have been correctly designed or analyzed from the theoretical point of view may, under real operating conditions, fail to function properly. The reason for this improper operation is seen, by the author, in the competition (race condition) between the normally open and normally closed contacts of the same relay. This situation is analyzed in some detail and it is pointed out that in a real device operational disruptions in the system as a result of race conditions can be eliminated by adjustments of the tension of the contact springs. Such adjustment does not normally, in the opinion of the author, meet the requirements of satisfactory operational reliability. Following this introductory section, there is a general review of existing works dealing with the study of relay systems operating with real contacts. The point is made that in all these papers the approach to the investigation of real-contact-

operating systems have been essentially the same: they are based on ready-made systems (of whatever method of construction), the operational correctness of which on ideal contacts is beyond any question, with a determination then made of the necessary and sufficient conditions which will guarantee proper system functioning when operating on real contacts. Three papers employing this general technique are reviewed and their findings are analyzed. The author's approach to the problem of achieving structures exempt from race conditions in the synthesis of systems operating under real conditions is fundamentally different; that is, the problem as formulated in the present paper is not one of finding a method of eliminating the race conditions from already designed relay systems, but rather one of finding a method of achieving, in the process of synthesis itself, systems free of such conditions. It is assumed that the operating conditions of the output of a relay device are described by a Boolean function

$$
\begin{aligned}
F &= (\tilde{x} \vee \tilde{y} \vee \ldots \vee \tilde{z}) \int (\tilde{x} \vee \tilde{y} \vee \ldots \vee \tilde{z}) \int \ldots \\
F &= (\bar{x} \int \bar{y} \int \ldots \int \bar{z}) \vee (\bar{x} \int \bar{y} \int \ldots \int \bar{z}) \vee \ldots
\end{aligned}
\qquad (1)
$$

A perfect normal form (disjunctive) of a Boolean function is considered. The problem of achieving the minimal form of the function F_{min} corresponds in a

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contact system to the minimum number of contacts. By way of example, the author has analyzed the synthesis of a system, the operating conditions of which are described by the function

$$F = xyz + xy\bar{z} + \bar{x}\bar{y}\bar{z} + x\bar{y}z + \bar{x}\bar{y}z + \bar{x}y\bar{z}. \qquad (2)$$

F_{min} is derived through the Quine method (W. Quine. A way to simplify truth functions. Amer. Math. Monthly, v. 59, n. 8, 1952; v. 62, n. 9, 1955). An entire set of simple implicants is first derived in the minimization. In his treatment of the problem, the author also makes use of tables given by McCluskey (E.J. McCluskey. Minimization of Boolean functions. Bell System Tech. J. XXXV, No. 6, 1956). Orig. art. has: 2 tables and 3 figures.

ASSOCIATION: none

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ACCESSION NR: AT4031771 S/0000/63/000/000/0180/0211

AUTHOR: Gavrilov, M. A.

TITLE: General method for the construction of bridge structures of (1, K)-networks

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 180-211

TOPIC TAGS: control system, automatic control, relay, relay structure, feedback, bridge structure

ABSTRACT: The author has previously (M. A. Gavrilov. Minimizatsiya bulevy*kh funktsiy, kharakterizuyushchikh releyny*ye tsepi. "Avtomatika i telemekhanika," no. 9, 1959) proposed a method for determining the general and particular minimal forms in a class of parallel-sequential structures, requiring the enumeration only of the working and forbidden states and thus free of the principal defect of other known methods. This method is known as the "probe method." In the paper mentioned above, the concept of the minimal term was introduced, which is defined as the term of a Boolean function containing the minimum number of letters: such a number of such letters that, if reduced by even one letter, this term will define not only the working state but at least one forbidden state. It was proven that the minimal form of the Boolean function, characterizing the structure of a relay device,

the operating conditions of which are assigned by the number of working states, contains only minimal terms which define all these states. Further investigation of this method has shown that it may also be effectively applied to the solution of the problem of bridge structure construction. This question is the subject of the present article. The author claims that he knows of only three works in which the intuition of the designer is replaced by a definite algorithm, determining the order of selection of the structural elements and the transition from one structural node to the other. The first of these, proposed by A. Sh. Blokh (Kanonicheskiy metod sinteza elektronny*kh skhem. Trudy* Instituta mashinizatsii i avtomatizatsii AN BSSR, no. 1, 1961), consists in the construction of a canonical table and is based entirely on the divisability of the structure circuits, which prevents the utilization of all possibilities for the construction of bridge structures. In addition, each of the canonical tables is built for a definite arrangement of the row-variable ribs of the tree, which requires inspection of the variants in order for the most rational solution to be obtained. The method involves a large number of operations. The second method, proposed by V. N. Roginskiy (Elementy* strukturnogo sinteza releyny*kh skhem upravleniya. Is-vo AN SSSR, 1959) is based, like the first, on the sequential building of structural nodes from the finite to the initial with a definite order of arrangement of the acting circuits of the relay elements in the structure of the device. In the third method, proposed by

F. Svoboda (Uziti neurcite dvonhodnotive Booleovy funkce na synthesu jednotaktnyich hradlovych shemat. Stroje na spracovani informaci. Sbor. 2, CSAV. Praha, 1954), the same order in the construction of a (1, K)-network structure is employed; however, the sequence of the variables is not fixed and at each node there is a selection both of the number of subsequent nodes and of the composition of the acting organs of the elements occurring in the circuits running to these nodes. The large number of operations required in these methods leads to the fact that even with four or five variables their use in manual synthesis is difficult and when mechanized requires a great deal of machine time or (in the case of special machines) — a large amount of equipment. The reason for the unwieldiness of these methods is seen by the author primarily in the fact that they require consideration of all the 2^n states (i.e., the working and forbidden, as well as the conditional states), although in principle the operating conditions of a relay device are completely determined by an enumeration of the states relating to any two of these three categories of states. (The point is emphasized that this defect is inherent in the majority of the methods published on minimization in the class of parallel-sequential structures.) What the method proposed in this article does (and this is, in the author's view, the most rational approach) is to determine these conditions by means of the working and forbidden states, since in relay devices employed in actual practice the number of conditional states increases as a function of an increasing number of variables far more rapidly than the number of working and forbidden

states. The author has represented the bridge structure of a (1, K)-network in the form of a certain graph, in which each apex corresponds to one of the nodes of the structure and each rib to the direct structural conductivity of the circuit between the corresponding nodes (that is, to the structural conductivity of the circuit running between the given nodes and entering no other nodes). The graph is oriented by matching certain of its apices with the initial and terminal nodes of the (1, K)-network (Fig. 1 of the Enclosure). The structure of the (1, K)-network is constructed so that each of the ribs represents the conductivity of a single acting organ of a relay element or their parallel connection, which will correspond to building a relay device structure in which each internodal circuit will contain one or several parallel-connected acting organs. Such ribs the author calls "elementary." When building such a graph, the initial and terminal nodes are given, while for each of the latter a table of states is known which characterizes the operating conditions of the relay element and the relay circuits which are to be realized between the initial node and each of the terminal nodes. It is necessary to determine the number of graph apices required for this purpose and all the reentering of the elementary ribs of the graph, including those reenterings and conductivities equal to zero or unity. The author describes in detail the operations involved in transforming the state tables, considering first a particular case in which, in the tables, for each of the output nodes of the structure there are identical conditional states. Orig. art. has: 32 tables and 14 figures.

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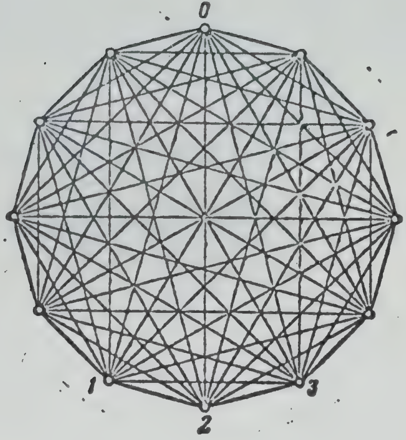

Fig. 1. Graph with elementary ribs 0 — apex corresponding to initial node; 1, 2, 3 — apices corresponding to terminal nodes

Ak132

ACCESSION NR: AT4031772 S/0000/63/000/000/0212/0225

AUTHOR: Didenko, V. P.

TITLE: Tabular-analytical method of constructing bridge-type relay-contact structures

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 212-225

TOPIC TAGS: control system, automatic control, feedback, relay, bridge structure, relay contact structure

ABSTRACT: In the author's view, synthesis methods for bridge structures may be divided into two classes. The first class includes those methods which use as basic data Boolean functions in perfect normal form, which describe the operation of the relay circuits. The basic data are usually presented in the form of state tables. A defect of the methods of this group is the fact that, in many cases, the constructed circuits are not, as a rule, minimal in terms of the number of elements. The methods of the second class are based on the use of minimum expressions of Boolean functions as basic data, and either are applicable only when constructing a narrow class of systems or else are extremely cumbersome, requiring as they do a continuous graphic representation and analysis of the system

to be synthesized. In view of the need, therefore, for the further investigation and development of methods for building bridge-type structures, the author has proposed that such studies be oriented towards an assignment of the initial (base) data in the guise of minimal forms which are derived in advance from the operating conditions of the relay device. In the present paper, the author has suggested an analytic method for building such bridge-type structures which is, in essence, a further development of the short-circuit methods and false-path analysis method originally proposed by M. A. Gavrilov (Minimizatsiya bulevy*kh funktsiy, kharakterizuyushchikh releyny*ye tsepi. "Avtomatika i telemekhanika," v. 16, no. 15, 1952; Strukturnaya teoriya releyny*kh ustroystv. Izd-vo MVO SSSR. 1956). The method is general in nature and may be used in the construction of all known classes of functions, including (p, q)-networks. The method is based on the alternation of discrimination operations for initial values α, the discrimination of bridge elements β and the comparison of working and forbidden states. The order in which the operations are described corresponds to the order in which they are applied. The sequence of operations is described in the article as follows: 1. Operation α is applied to a given (in minimal form) Boolean function. As a result of this operation, let there be separated q initial elements: x_1, $x_2, \ldots, x_q$. 2. The prescribed function is transformed so that the initial elements selected are removed from the parentheses. 3. By means of operation β, a check is

made of the possibility of discriminating the bridge element between each pair of initial elements. 4. After the bridge element has been separated, those terms of the functions which contain it (that is, the bridge element) are placed in parentheses as constructed. 5. A review is made of all the tables which contain the initial elements $x_1, x_2, \ldots, x_q$. Terms written on the same line and not placed in parentheses in a single table containing $x_i (1 \leq i \leq q)$ give, in sum, a function, designated as f_{x_i}. All as yet unconstructed functions are determined. 6. Operation α is applied to function f_{x_i}. 7. Operation β is applied to each pair of initial elements so compiled that the first element of the pair is discriminated by the second application of operation α, and the second element by the first application of operation α. 8. If new terms arise during the separation of the bridge element, operation γ is applied. 9. Rule 5 is repeated for function $f_{x_{i+1}}$. 10. Rule 6 is repeated for the initial elements separated by the third application of operation α. 11. Operation β is applied to each pair of initial elements, such as that the new element of the pair was separated by the second application of operation α, and the second element — by the third application of the same operation. 12. If new terms arise during operation β, rule 7 is repeated. The article contains an example showing the application of the method to the synthesis of the bridge structure of a multicycle (1, K)-network. The advantages of the

method discussed in the article consist in its applicability to the synthesis of any classes of circuits and in its consideration of all conditions for structural simplification. Moreover, the method readily lends itself to mechanization, since it is equivalent to a verification of discriminated bridge elements by forbidden states. The initial elements are separated by computing on a calculator the number of their appearances in the function. The formation of the circuit during the construction process may be tabulated. Orig. art. has: 2 figures, 6 tables and 8 formulas.

ASSOCIATION: none

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B315

Ax13-25

ACCESSION NR: AT4031773

S/0000/63/000/000/0226/0236

AUTHOR: Ostianu, V. M.

TITLE: Nonsymmetrical codes with ring metrics

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 226-236

TOPIC TAGS: control system, automatic control, relay, code, nonsymmetrical code, ring metric, code distance, linear code, binary code

ABSTRACT: The author first considers a class of non binary codes with metrics determined by the ratio

$$\rho(\alpha, \beta) = \sum_{i=1}^{n} \rho(\alpha_i, \beta_i) \qquad (1)$$

where α and β are code words, and

$$\rho(\alpha_i, \beta_i) = \begin{cases} \min\{(\alpha_i - \beta_i),\ (b - \alpha_i + \beta_i)\}, & \text{if } \alpha_i \geqslant \beta_i \\ \min\{(\beta_i - \alpha_i),\ (b - \beta_i + \alpha_i)\}, & \text{if } \beta_i > \alpha_i \end{cases} \qquad (2)$$

The minimum distance between code words is called the code distance. A theorem is derived and proved which states that the code distance of the union and the sum of the two subgroups $\Delta 1_{n,b}$ and $\Delta 2_{n,b}$ of group $G'_{n,b}$ are equal. On the basis of this theorem, the author proposes the construction of linear codes with ring metrics. Three definitions are introduced: 1. A code containing the greatest number of words is called a maximal code. 2. A linear code, maximal in a class of linear codes, is called a linear-maximal code. 3. A quasimaximal code is a linear-maximal code $g_{n,b}$ for which at $G'_{n,b}/g_{n,b}$ no single word exists which stands at a distance less than D from all its elements. Any binary linear-maximal code is quasimaximal. This assertion is not valid for non-binary codes with equiprobable distortions. An example is given to prove this point. A second theorem is derived

$$p^m = p^n + \left[-\log_p (2n + 1)\right]. \quad (3)$$

Since this ratio is valid for any systematic codes with the metrics of Eq. (1), thus on the basis of this theorem it may be stated that linear codes with the metrics of Eq. (1), which

correct single errors, are maximal in a class of systematic codes. An estimate is made from above of the power of such a code, with correction of d errors. An analogous problem is formulated in a more general form, in which it is assumed that in the transmitted message each j-th ($j = 1, \ldots, n$) symbol may be distorted by not more than a t_j-multiple error ($t_j \geq 1$). Here, as in the preceding case, interference of two types, distorting the symbols of the transmitted word in one of two opposite directions, is considered. Whereas for the preceding case the solution was written in the form

$$b^h > 1 + \sum_{s=1}^{d} \sum_{k=k_1}^{k_2} \sum_{v=0}^{s} (-1)^v 2^k C_s^k C_k^v C_{s-1-vt}^{k-1} . \qquad (4)$$

in this case the solution appears as

$$b^h > 1 + \sum_{s=1}^{d} \sum_{k=k}^{k_2} \sum_{l=0;\ \varphi_2^{(l)}(0)\neq 0}^{s} (-1)^{v+k} 2^k C_{s-l+k-l}^{k-l} . \qquad (5)$$

If $t_1 = t_2 = \ldots = t_k = t$, the two formulas coincide. In a further development of the subject, the code base b is assumed to be an even number, in which case any letter of the transmitted word may undergo not more than a ($\frac{b}{2} - 1$)-multiple distortion of one type, and not more than a $\frac{b}{2}$- multiple distortion of the other type. Then the number of verification

symbols h in a code capable of correcting d-multiple distortions must satisfy the inequality $b^h \geqslant R_2 + 1$, where R_2 is the number of code words which the transmitted message may assume with all possible distortions by not more than d-multiple errors. The solution

$$b^h \geqslant 2n + 1, \tag{6}$$

is in agreement with the estimate of W. Ulrich (Non-binary error-correcting codes. BSTY, V. XXXVI, no. 6, p. 1341-1389, 1957). In the concluding section of the article, the maximal value of the code distance D is determined with N, n and b given. The solution is given in the form

$$D < n\frac{N^2 b\,2}{8N(N-1)} = n\frac{Nb}{4(N-1)}. \tag{7}$$

Orig. art. has: 2 figures and 8 numbered formulas.

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Card 5/5

ACCESSION NR: AT4031774 S/0000/63/000/000/0237/0241

AUTHOR: Zhozhikashvili, V. A.; Raykin, A. L.

TITLE: Determination of the suitable operating conditions of a system reserve unit

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 237-241

TOPIC TAGS: control system, automatic control, feedback, relay, reserve unit, system reliability, system design

ABSTRACT: A well-known method for enhancing system reliability is the introduction of structural redundancy (in specific cases, the duplication of its elements or units). In the present article, a system is considered which consists of a basic and stand-by (reserve) unit, and the mission of which is the uninterrupted fulfillment of its assigned functions. With the basic unit functioning normally, the stand-by is in the condition of 'cold' reserve, characterized by an outage time distribution law differing from the outage time distribution of the basic equipment, and is put into operation only in the event of a failure of the basic unit. Outages of the working unit are signaled and eliminated by service personnel. It is further assumed that there is a fault detector which activates the stand-by switch-on

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elements (Fig. 1 of the Enclosure). Considering, for the sake of simplicity, these supplementary elements to be absolutely reliable, the authors have attempted to determine the advantages of this method of stand-by (reserve), as they result from the less exacting conditions of the stand-by unit, as well as its shortcomings, which are connected with the lack of information regarding the state of the stand-by unit elements when the basic equipment is operating properly. The discussion concerns systems, the operational "ready" time of which is negligibly small. In a general case, the solution of the problem presupposes arbitrary time distribution laws for the faults of the stand-by and basic units and of the fault restoration times. In this paper, a uniform case is considered, in which these distribution laws have a constant conditional probability density, with instantaneous switch-on of the reserve equipment. With this formulation, the behavior of the system represents a random Markov process with four states, designated as follows: (11) - both units in working order, with the basic unit fulfilling its assigned functions; (01) - basic unit "out" and under repair, with the stand-by unit in order and fulfilling the functions of the basic; (10) - basic unit in order and functioning properly, with the stand-by unit "out", but with no information to that effect; (00) - both units out, indicating a failure of the entire system. The possibilities of transitions from one state to the other and their conditional probability

densities are indicated in Fig. 2 of the Enclosure. The author has designated the probabilities of the system being in these states as time functions $P_{11}(t)$, $P_{10}(t)$, $P_{01}(t)$, and $P_{00}(t)$, respectively, and has also introduced the notation λ_1 and λ_2 for the intensities and conditional probability densities of faults in the basic and stand-by units, respectively, and μ = the speed of fault restoration. Thus, a formula is derived

$$T_{mean} = \frac{\lambda_2 \mu}{\lambda_1(\rho_1+\lambda_1)(\rho_2+\lambda_1)} - \frac{\lambda_1\lambda_2(\rho_1+\lambda_1+\mu)}{\rho_1^2(\rho_1+\lambda_1)(\rho_2-\rho_1)} + \frac{\lambda_1\lambda_2(\rho_2+\lambda_1+\mu)}{\rho_2^2(\rho_2+\lambda_1)(\rho_2-\rho_1)} - \frac{\lambda_1^2(\rho_1+\rho_2)}{\rho_1^2\rho_2^2} \qquad (1)$$

for the mean failure-free operating time of a duplicated (stand-by) system as a function of three parameters: the intensity values of the outages of the basic and stand-by units and the speed of restoration. An estimation of this type makes it possible to compare achievable reliability with the reserve facilities employed in different manners. The author has called attention to the need to extend this method to cases of arbitrary fault time distribution laws, since this would permit consideration of the effect of element aging. Orig. art. has: 3 figures and 13 formulas.

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ASSOCIATION: none

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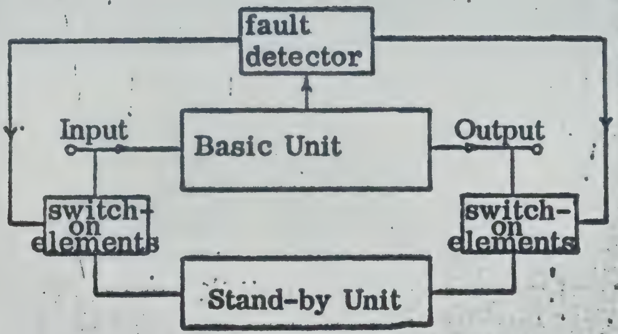
fault detector
Input
Basic Unit
Output
switch-on elements
switch-on elements
Stand-by Unit

Fig. 1

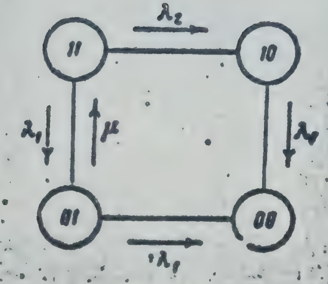

Fig. 2

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ACCESSION NR: AT4031775 S/0000/63/000/000/0242/0249

AUTHOR: Timofeyev, B. L.

TITLE: Machine for the minimization of Boolean functions (Machine for the synthesis of relay circuits in class Π)

SOURCE: AN SSSR. Strukturnaya teoriya releyny*kh ustroystv (Structural theory of relay devices). Moscow, Izd-vo AN SSSR, 1963, 242-249

TOPIC TAGS: control system, automatic control, relay, relay circuit synthesis, Boolean function, minimization, Boolean function minimization

ABSTRACT: The machine described in this paper for the minimization of Boolean functions constitutes an experimental verification of the machine algorithm developed by the author on the basis of the probe method proposed by M. A. Gavrilov (Minimizatsiya bulevy*kh funktsiy, kharakterizuyushchikh releyne*ye tsepi. "Avtomatika i telemekhanika", v. 20, no. 9, 1959). This algorithm makes it possible to obtain minimal forms for functions of up to 10-11 variables. At the present time, a mockup of the machine has been built for finding simple implicants of Boolean functions from six variables. This is the first part of the machine. Constraints are fed into the machine by means of a

standard perforated card with 45 columns. Each aperture of the card corresponds to a term of a perfect normal disjunctive form of a Boolean function describing a relay circuit. The working and forbidden states of the circuit are assigned. Conditional states are taken into account automatically by the machine. Any function involving eight variables can be written on one card. The machine solves its problem in two stages. During the first stage, all terms of the common minimal form of the given function are determined; during the second stage, from these terms different expressions are compiled, equivalent to the given function, from which the minimal are selected. The number of these forms may vary, depending on the type of problem and the requirements levied on the final answer, since in a general case the larger the number of such forms obtained, the better will be the one selected, on the basis of one or another criterion of minimality. The final result may be read out visually or printed out on a special electric printer. In addition, the intermediate results, which go to make up the final solutions of the problems, may also be read out visually or printed out by machine. Both the minimal form algorithm and the machine itself (on the basis of a block diagram) are described in some detail in the article. As stated above, in accordance with the algorithm for finding the minimal forms, described in the paper, the machine uses a two-stage problem-solution approach. First, all simple implicants of disjunction of the unity constituents are found, which express the

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working and unusable states (but which are implicants not only of the unusable states); then, from these implicants there are constituted different variants of a relay circuit having prescribed working and forbidden states. From the variants found, the minimal are selected. The block diagram adopted permits the creation of a machine operating with ten variables. As already stated, input to the machine is by means of a perforated card which is an operational memory and makes possible the read out of its stored information at a rate of up to 200-300 thousand constituents per second. The algorithms, on the basis of which this particular machine was constructed, do not permit the design of a machine for class-Π synthesis for a large number of variables, for example for 20. However, the algorithms known at the present time which would permit the creation of such a machine give, the author claims, a worse result for 10-11 variables than the machine described in this article. Orig. art. has: 1 figure and 4 tables.

ASSOCIATION: none

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